

CLAIMS

1. A switching regulator that is a step-down
switching regulator for converting a voltage applied on
5 an input terminal to a predetermined voltage and
outputting the predetermined voltage from an output
terminal, said switching regulator comprising:

a switching transistor formed from a PMOS
transistor configured to switch ON or switch OFF output
10 of the input voltage according to a control signal input
to a control electrode;

a smoothing circuit configured to smooth the
output voltage from the switching transistor and output
the smoothed voltage to the output terminal;

15 a selection circuit configured to control
connection of a substrate gate of the switching
transistor according to the input control signal; and

a switching transistor control circuit
configured to control a switching operation of the
20 switching transistor so that the voltage output from the
output terminal becomes the predetermined voltage;

wherein

the selection circuit connects the substrate
gate to a drain of the switching transistor when the
25 voltage on the input terminal is less than or equal to

the voltage on the output terminal, and connects the substrate gate to a source of the switching transistor when the voltage on the input terminal is greater than the voltage on the output terminal.

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2. The switching regulator as claimed in claim 1, further comprising:

a selection control circuit that compares the voltage on the input terminal to the voltage on the output terminal, and controls the selection operation of the selection circuit according to a comparison result;

wherein

the selection control circuit controls the selection circuit to connect the substrate gate to the drain of the switching transistor when the voltage on the input terminal is less than or equal to the voltage on the output terminal, and controls the selection circuit to connect the substrate gate to the source of the switching transistor when the voltage on the input terminal is greater than the voltage on the output terminal.

3. The switching regulator as claimed in claim 1, wherein

the selection operation of the selection

circuit is controlled by an external selection control circuit according to the voltage on the input terminal and the voltage on the output terminal so that the selection circuit is controlled to connect the substrate
5 gate to the drain of the switching transistor when the voltage on the input terminal is less than or equal to the voltage on the output terminal, and connect the substrate gate to the source of the switching transistor when the voltage on the input terminal is higher than the
10 voltage on the output terminal.

4. The switching regulator as claimed in claim 2, further comprising:

a switching circuit that connects a gate of
15 the switching transistor to the drain of the switching transistor;

wherein

when the voltage on the input terminal is less than or equal to the voltage on the output terminal,
20 based on a control signal from the selection control circuit, the switching circuit connects the gate of the switching transistor to the drain of the switching transistor while the switching transistor control circuit stops output of the control signal to the gate of the
25 switching transistor; and

when the voltage on the input terminal is greater than the voltage on the output terminal, based on the control signal from the selection control circuit, the switching circuit disconnects the gate of the
5 switching transistor from the drain of the switching transistor while the switching transistor control circuit outputs the control signal to the gate of the switching transistor.

10 5. The switching regulator as claimed in claim 4, wherein the switching circuit includes a field effect transistor (FET).

15 6. The switching regulator as claimed in claim 1, wherein the selection circuit includes a field effect transistor (FET).

20 7. The switching regulator as claimed in claim 4, wherein the smoothing circuit includes a synchronization rectification transistor that is connected to the switching transistor in series and is controlled by the switching transistor control circuit to be switched on or switched off,

wherein
25 the switching transistor, the synchronization

rectification transistor, the selection circuit, the selection control circuit, the switching transistor control circuit, and the switching circuit are integrated into one IC chip.

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8. The switching regulator as claimed in claim 4, wherein the smoothing circuit includes a synchronization rectification transistor that is connected to the switching transistor in series and is controlled by the switching transistor control circuit to be switched on or switched off,

wherein

the switching transistor, the synchronization rectification transistor, the selection circuit, the switching transistor control circuit, and the switching circuit are integrated into one IC chip.

9. A power supply circuit, comprising:
one or more step-down switching regulators
configured to convert a voltage applied on an input terminal to a predetermined voltage and output the predetermined voltage from an output terminal; and

one or more linear regulators;

wherein

the switching regulator includes

a switching transistor formed from a PMOS transistor configured to switch ON or switch OFF output of the input voltage according to a control signal input to a control electrode;

5 a smoothing circuit configured to smooth the output voltage from the switching transistor and output the smoothed voltage to the output terminal;

a first selection circuit configured to control connection of a substrate gate of the switching transistor according to the input control signal, the first selection circuit connecting the substrate gate to a drain of the switching transistor when the voltage on the input terminal is less than or equal to the voltage on the output terminal, and connecting the substrate gate to a source of the switching transistor when the voltage on the input terminal is greater than the voltage on the output terminal; and

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a switching transistor control circuit configured to control a switching operation of the switching transistor so that the voltage output from the output terminal becomes the predetermined voltage.

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10. The power supply circuit as claimed in claim 9, wherein the linear regulator comprises:

25 a voltage control transistor that includes a

PMOS transistor configured to control a current from the input terminal to the output terminal to control the voltage on the output terminal;

a second selection circuit configured to
5 control connection of the substrate gate of the voltage control transistor;

a second switching transistor control circuit configured to control a switching operation of the switching transistor so that the voltage output from the
10 output terminal becomes the predetermined voltage;

a second selection control circuit that controls the selection operation of the selection circuit according to the voltage on the input terminal and the voltage on the output terminal, the second selection
15 circuit connecting the substrate gate to a drain of the voltage control transistor when the voltage on the input terminal is less than or equal to the voltage on the output terminal, and connecting the substrate gate to a source of the voltage control transistor when the voltage
20 on the input terminal is greater than the voltage on the output terminal; and

a voltage control transistor control circuit configured to control the voltage control transistor so that the voltage output from the output terminal becomes
25 the predetermined voltage.

11. The power supply circuit as claimed in claim 9, wherein the switching regulator further comprises:

5 a first selection control circuit that compares the voltage on the input terminal to the voltage on the output terminal, and controls the selection operation of the first selection circuit according to a comparison result;

10 wherein

 the first selection control circuit controls the first selection circuit to connect the substrate gate to the drain of the switching transistor when the voltage on the input terminal is less than or equal to the
15 voltage on the output terminal, and controls the first selection circuit to connect the substrate gate to the source of the switching transistor when the voltage on the input terminal is greater than the voltage on the output terminal.

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12. The power supply circuit as claimed in claim 9, wherein

 the selection operation of the first selection circuit is controlled by an external selection control
25 circuit according to the voltage on the input terminal

and the voltage on the output terminal so that the first selection circuit is controlled to connect the substrate gate to the drain of the switching transistor when the voltage on the input terminal is less than or equal to
5 the voltage on the output terminal, and connect the substrate gate to the source of the switching transistor when the voltage on the input terminal is greater than the voltage on the output terminal.

10 13. The power supply circuit as claimed in claim 11, wherein the switching regulator further comprises:

 a switching circuit that connects a gate of the switching transistor with the drain of the switching
15 transistor;

 wherein

 when the voltage on the input terminal is less than or equal to the voltage on the output terminal, based on a control signal from the first selection
20 control circuit, the switching circuit connects the gate of the switching transistor to the drain of the switching transistor while the switching transistor control circuit stops output of the control signal to the gate of the switching transistor; and

25 when the voltage on the input terminal is

greater than the voltage on the output terminal, based on the control signal from the first selection control circuit, the switching circuit disconnects the gate of the switching transistor from the drain of the switching transistor while the switching transistor control circuit
5 outputs the control signal to the gate of the switching transistor.

14. The power supply circuit as claimed in
10 claim 13, wherein the smoothing circuit includes a synchronization rectification transistor that is connected to the switching transistor in series and controlled by the switching transistor control circuit to be switched on or switched off,

15 wherein
the switching transistor, the synchronization rectification transistor, the first selection circuit, the first selection control circuit, the switching transistor control circuit, the switching circuit, and
20 the linear regulator are integrated into one IC chip.

15. The power supply circuit as claimed in claim 13, wherein the smoothing circuit includes a synchronization rectification transistor connected to the
25 switching transistor in series and controlled by the

switching transistor control circuit to be switched on or
switched off,

wherein

the switching transistor, the synchronization
5 rectification transistor, the first selection circuit,
the switching transistor control circuit, the switching
circuit, and the linear regulator are integrated into one
IC chip.

10 16. A power supply circuit, comprising:

a plurality of step-down switching regulators
each configured to convert a voltage applied on an input
terminal to a predetermined voltage and output the
predetermined voltage from an output terminal,

15 wherein

each of the switching regulators includes
a switching transistor formed from a PMOS
transistor configured to switch ON or switch OFF output
of the input voltage according to a control signal input
20 to a control electrode;

a smoothing circuit configured to smooth
the output voltage from the switching transistor and
output the smoothed voltage to the output terminal;

a selection circuit configured to control
25 connection of a substrate gate of the switching

transistor according to the input control signal, the selection circuit connecting the substrate gate to a drain of the switching transistor when the voltage on the input terminal is less than or equal to the voltage on the output terminal, and connecting the substrate gate to a source of the switching transistor when the voltage on the input terminal is greater than the voltage on the output terminal; and

a switching transistor control circuit configured to control a switching operation of the switching transistor so that the voltage output from the output terminal becomes the predetermined voltage.

17. The power supply circuit as claimed in claim 16, wherein the switching regulator further comprises:

a selection control circuit that compares the voltage on the input terminal to the voltage on the output terminal, and controls the selection operation of the selection circuit according to a comparison result;

wherein

the selection control circuit controls the selection circuit to connect the substrate gate to the drain of the switching transistor when the voltage on the input terminal is less than or equal to the voltage on

the output terminal, and controls the selection circuit to connect the substrate gate to the source of the switching transistor when the voltage on the input terminal is greater than the voltage on the output
5 terminal.

18. The power supply circuit as claimed in claim 16, wherein the selection operation of the selection circuit is controlled by an external selection
10 control circuit according to the voltage on the input terminal and the voltage on the output terminal so that the selection circuit is controlled to connect the substrate gate to the drain of the switching transistor when the voltage on the input terminal is less than or
15 equal to the voltage on the output terminal, and connect the substrate gate to the source of the switching transistor when the voltage on the input terminal is greater than the voltage on the output terminal.

20 19. The power supply circuit as claimed in claim 17, wherein the switching regulator further comprises:

a switching circuit that connects a gate of the switching transistor with the drain of the switching
25 transistor;

wherein

when the voltage on the input terminal is less than or equal to the voltage on the output terminal, based on a control signal from the selection control
5 circuit, the switching circuit connects the gate of the switching transistor to the drain of the switching transistor while the switching transistor control circuit stops output of the control signal to the gate of the switching transistor; and

10 when the voltage on the input terminal is greater than the voltage on the output terminal, based on the control signal from the selection control circuit, the switching circuit disconnects the gate of the switching transistor from the drain of the switching
15 transistor while the switching transistor control circuit outputs the control signal to the gate of the switching transistor.

20 20. The power supply circuit as claimed in claim 19, wherein the smoothing circuit includes a synchronization rectification transistor that is connected to the switching transistor in series and is controlled by the switching transistor control circuit to be switched on or switched off,

25 wherein

the switching transistor, the synchronization
rectification transistor, the selection circuit, the
selection control circuit, the switching transistor
control circuit, and the switching circuit are integrated
5 into one IC chip.

21. The power supply circuit as claimed in
claim 19, wherein the smoothing circuit includes a
synchronization rectification transistor that is
10 connected to the switching transistor in series and is
controlled by the switching transistor control circuit to
be switched on or switched off,

wherein

the switching transistor, the synchronization
15 rectification transistor, the selection circuit, the
switching transistor control circuit, and the switching
circuit are integrated into one IC chip.

22. A secondary cell charging circuit,
20 including a step-down switching regulator configured to
convert a voltage applied on an input terminal to a
predetermined voltage and output the predetermined
voltage from an output terminal, a secondary cell being
connected to the output terminal,

25 wherein

the switching regulator comprises:

a switching transistor formed from a PMOS transistor configured to switch ON or switch OFF output of the input voltage according to a control signal input
5 to a control electrode;

a smoothing circuit configured to smooth the output voltage from the switching transistor and output the smoothed voltage to the output terminal;

a selection circuit configured to control
10 connection of a substrate gate of the switching transistor according to the input control signal, the selection circuit connecting the substrate gate to a drain of the switching transistor when the voltage on the input terminal is less than or equal to the voltage on
15 the output terminal, and connecting the substrate gate to a source of the switching transistor when the voltage on the input terminal is greater than the voltage on the output terminal; and

a switching transistor control circuit
20 configured to control a switching operation of the switching transistor so that the voltage output from the output terminal becomes the predetermined voltage.

23. The secondary cell charging circuit as
25 claimed in claim 22, wherein the switching regulator

further comprises:

a selection control circuit that compares the voltage on the input terminal to the voltage on the output terminal, and controls the selection operation of the selection circuit according to a comparison result;

wherein

the selection control circuit controls the selection circuit to connect the substrate gate to the drain of the switching transistor when the voltage on the input terminal is less than or equal to the voltage on the output terminal, and controls the selection circuit to connect the substrate gate to the source of the switching transistor when the voltage on the input terminal is greater than the voltage on the output terminal.

24. The secondary cell charging circuit as claimed in claim 22, wherein the selection operation of the selection circuit is controlled by an external selection control circuit according to the voltage on the input terminal and the voltage on the output terminal so that the selection circuit is controlled to connect the substrate gate to the drain of the switching transistor when the voltage on the input terminal is less than or equal to the voltage on the output terminal, and connect

the substrate gate to the source of the switching transistor when the voltage on the input terminal is greater than the voltage on the output terminal.

5 25. The secondary cell charging circuit as claimed in claim 23, wherein the switching regulator further comprises:

 a switching circuit that connects a gate of the switching transistor with the drain of the switching
10 transistor;

 wherein

 when the voltage on the input terminal is less than or equal to the voltage on the output terminal, based on a control signal from the selection control
15 circuit, the switching circuit connects the gate of the switching transistor to the drain of the switching transistor while the switching transistor control circuit stops output of the control signal to the gate of the switching transistor; and

20 when the voltage on the input terminal is greater than the voltage on the output terminal, based on the control signal from the selection control circuit, the switching circuit disconnects the gate of the switching transistor from the drain of the switching
25 transistor while the switching transistor control circuit

outputs the control signal to the gate of the switching transistor.

26. The secondary cell charging circuit as
5 claimed in claim 25, wherein the smoothing circuit
includes a synchronization rectification transistor that
is connected to the switching transistor in series and is
controlled by the switching transistor control circuit to
be switched on or switched off,
10 wherein
the switching transistor, the synchronization
rectification transistor, the selection circuit, the
selection control circuit, the switching transistor
control circuit, and the switching circuit are integrated
15 into one IC chip.

27. The secondary cell charging circuit as
claimed in claim 25, wherein the smoothing circuit
includes a synchronization rectification transistor that
20 is connected to the switching transistor in series and is
controlled by the switching transistor control circuit to
be switched on or switched off,
wherein
the switching transistor, the synchronization
25 rectification transistor, the selection circuit, the

switching transistor control circuit, and the switching circuit are integrated into one IC chip.